Legumes On-Farm Testing and Nursery Unit (LEGOFTEN)

A Brief Report of Work
June 1987 - June 1991

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

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This brief report has been prepared to share the information with scientists who have interest in transfer of technology to farmers.

The volume of data collected during the course of LECOFTEN activities from 1987-91 was so enormous to print that we had to ultimately produce a brief summary report at the end of the project. The Annual Reports of work from 1987-1989 and some booklets on important aspects of improved technologies were produced for limited circulation. Further, some papers were also produced for external publications. Anyone with an interest in more detailed information should contact LECOFTEN.

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LECOFTEN

CONTENTS

1. PREAMBLE

One of the objectives of ICRISAT is to assist the national and regional research programs in the development and transfer of technology to the farmer through co-operation and by sponsoring workshops and conferences, operating training programs, and assisting extension activities.

2. LEGOFTEN - STRUCTURE AND PROGRAM

2.1 Introduction

In 1987, the Union Ministry of Agriculture, India, requested ICRISAT to consider helping the national programs in transfer of technology for increasing the production of legumes in India, and to co-ordinate this activity for an initial period. The request was initially made for groundnut, and later extended (in 1988) for the other two legume crops (pigeonpea and chickpea) of ICRISAT's, mandate.

In response, the Legumes Program of ICRISAT established a 'Legumes On-Farm Testing and Nursery Unit' (LEGOFTEN) to facilitate transfer of production technology for legumes to the Indian farmer.

2.2. Staffing

The Unit initially comprised three scientists with eight supporting staff drawn from different research units of the Legumes Program. In 1988, with the addition of pigeonpea and chickpea, the Unit was strengthened to have four scientists and leven supporting staff. From 1989 onwards as the transfer of technology program progressed and the national programs began to take over responsibility for the work, the LEGOFTEN staff was reduced and at present (1991) the strength of LEGOFTEN is one scientist and nine supporting staff.

2.3 Funding

In the first two years of its operation, the LEGOPTEN project was funded from the annual budget of the Legumes Program, ICRISAT, but from 1989 funding has been provided by the International Fund for Agricultural Development (IFAD), Rome, Italy, as a part of its technical assistance for the purposes of "Research on Groundnut, Pigeonpea and Chickpea and Transfer of Technology to the Semi-Arid Tropics Farmers".

2.4 Program Planning

Before the start of LEGOPTEN activities in 1987, a meeting of key officials of the Union Ministry of Agriculture, State Departments of Agriculture, Indian Council of Agriculture Research (ICAR), and ICRISAT scientists was convened at ICRISAT Center, Patancheru P.O., A.P. 502 324, India, to discuss and plan the modus operandi for the transfer of technology. It was decided to undertake the work in two phases:

Phase I: Under this phase ICRISAT was to - a) educate extension workers of the Departments of Agriculture on appropriate production technology by conducting on-farm trials at the seed farms of the Departments of Agriculture, b) conduct and monitor the trials in cooperation with extension workers so that they understand all the components of technology and realise their benefit, and c) clear the doubts of extension workers on the suitability of the technology during on-farm trials.

Phase II: Under this phase ICRISAT would - a) encourage extension workers to conduct similar on-farm trials as demonstrations in farmers' fields, b) advise and assist extension workers to educate their colleagues and also farmers on the new technology by organising

field-days at these demonstrations, and c) conduct training programs/meetings on request from extension workers at various places to educate more and more farmers on the technology.

It was also decided that before every cropping season ICRISAT would call in selected extension workers and seed farm managers of the Departments of Agriculture for 2-3 day Orientation-cum-Training Workshops at ICRISAT Center to ensure that the on-farm trials would be properly planned and executed.

The above procedure was followed until the postrainy season of 1989-90, when a decision was taken jointly by ICAR and ICRISAT officials to include the LEGOFTEN activities under the regular ICAR/ICRISAT biannual work plans. In the 1989 ICAR/ICRISAT meeting ICAR scientists indicated interest to contribute their knowledge, technical know-how, and expertise in the transfer of technology to farmers. Accordingly, two projects on transfer of technology, one relating to groundnut and the other relating to pigeonpea were approved while the proposal related to chickpea was deffered. The approved projects (ICRISAT-ICAR-GNT-8; ICRISAT/ICAR-PNP 8), which were mainly to evaluate the technology at the national research centers, were put forward for approval at the regular annual workshops of the respective All India Coordinated Crop Improvement Programs (AICCIP).

In 1990, a development oriented organisation, the National Dairy Development Board (NDDB) and its subsidiaries the State Cooperative Oilseeds Growers' Federations (SCOGFs), which were involved in on-farm trials of groundnut from the beginning, proposed direct collaboration with ICRISAT for the transfer of production technology of groundnut on a large scale. This was agreed to, and ICRISAT is further helping the NDDB and

SCOGFs in their efforts of transferring the technology to farmers by providing advice, consultancies and training facilities.

The basic structure of activities undertaken by LEGOPTEN for the transfer of production technology of legumes in India is outlined in Fig. 1. ICRISAT has acted as a catalyst in the transfer of technology rather than get itself involved directly in extension, which is essentially a job for the national programs - the ICAR, Agricultural Universities, State Departments of Agriculture, and Agricultural Development Agencies.

2.4.1 Training

Before deciding upon the programs of on-farm trials for each crop, the identified extension workers and seed farm managers of the Departments of Agriculture and Development Agencies were called for a 2-3 day Orientation-cum-training Workshop at ICRISAT Center. These extension workers were orientated and trained thoroughly on production technology so that they were mentally and physically prepared for laying out the trials at their seed farms. Besides the theory, participants were given practical demonstrations on various components of the technology, particularly on shaping the land into broad-beds. They were asked to describe the packages of practices they currently follow for the crops so that these could be compared with the improved technologies. The improved and common packages for groundnut, pigeonpea, and chickpea production trials are compared in Tables 1, 2, and 3 respectively.

2.4.2 Technology

Basically, the improved technology advocated for production of groundnut, pigeonpea and chickpea consisted of two major components, improved package of practices, and improved varieties.

a) Improved package or practices: For each crop, this consisted of recommendations on - the land preparation, dosages of manures and fertilizers, seed-rate, seed treatment, spacing, weed control, pest and disease control, irrigation, harvesting etc., that have direct as well as indirect influence on the yield of the crop. A major recommendation was that for shaping the land after tillage into a raised-bed system (Fig. 2). For on-farm trials in particular, the broad-bed system (opening 30 cm wide and 22.5 cm deep parallel furrows 1.5 m apart to form the raised-beds) was recommended for growing the crops with sprinkler irrigation which was to be made available by the Departments of Agriculture to their seed farms.

b) Improved varieties: These were basically ICRISAT varieties either released or likely to be identified-for-release for cultivation in India. The varieties tested in on-farm trials for groundnut, pigeonpea and chickpea are listed in Table 4. ICRISAT supplied the breeder's seeds of these varieties for on farm trials so that the produce obtained from these trials could be used as seed for further trials/demonstrations in farmers' fields.

2.4.3 On-farm trials/demonstrations

In consultation with the officers and extension workers of the national programs, on-farm trials were to be conducted at the Taluka/District seed farms with the following four treatments, each covering 0.2 ha.

i) Improved package + Improved variety,

ii) Improved package + Common variety,

iii) Common package + Improved variety, and

iv) Common package + Common variety

The main objective of selecting the above four treatments for on-farm trials was to show the benefit of the improved package and improved varieties independent of each other and in combination over the common package and common varieties.

3. [redacted]

On-farm trials for groundnut production were conducted from the rainy season 1987 until the postrainy season 1990-91. Demonstrations of the improved technology were started a season or two later by extension workers of the national programs - the Departments of Agriculture and State Cooperative Oilseeds Growers' Federations.

3.1 On-farm trials

The numbers of on-farm trials conducted for groundnut in the rainy and postrainy seasons between 1987 and 1990 are given in Table 5. In the first two seasons all the trials were monitored by ICRISAT scientists while in subsequent years the trials were largely monitored by staff of the national programs. The average yield obtained in on-farm trials of different states for the rainy and postrainy seasons along with the benefits from technology are given in Table 6. With the improved package of practices alone, the yield benefit over the common package averaged 21.5% for the rainy season and 19% for the postrainy season. With improved varieties in common package the yield benefit averaged 26.4% for the rainy season and 26.2% for the postrainy season over common varieties. The total improved technology, that is, both the improved package of practices and improved varieties, gave an average yield benefit of 62% for the rainy season and 60.3% for the postrainy season over the commonly used technology. The yield benefit from the improved technologies did not vary much from year to year (Table 7).

In general, the improved technology required an average extra expenditure of Rs. 1505 ha^{-1} over the average expenditure of Rs. 6605 ha^{-1} for common technology. This extra expenditure gave a substantial extra net income of Rs. 5815 ha^{-1} over the average net income of Rs. 5395 ha^{-1} from the common technology.

3.2 On-farm demonstrations

Besides on-farm trials, the State Cooperative Oilseeds Growers' Federations and Departments of Agriculture conducted on-farm demonstrations parallel to on-farm trials. The data obtained for these on-farm demonstrations from the Federations are given in Tables 8-12 and from the Departments of Agriculture in Table 13. The yield benefits obtained from demonstrations of the improved technology were quite substantial and similar to those obtained in the on-farm trials; the benefit averaged 68.9% in Karnataka, 69% in Tamil Nadu, 33% in Maharashtra, 32% in Gujarat and 19.8% in Andhra Pradesh States.

3.3 Front-line on-farm trials (ICRISAT/ICAR)

As indicated earlier, the major component of the improved technology was that of growing the crop on raised-beds. This practice was always looked upon with some doubt as to its utility by the scientists of the national programs, while they agreed to all other components of the improved package. However, in 1989 when the ICAR/ICRISAT project was formulated for the transfer of groundnut production technology, the evaluation of raised-bed against flat-bed systems of land preparation was given high priority. The data from two seasons of trials conducted by the All India Coordinated Research Project on Oilseeds (AICORPO) are given in Table 14. At most AICORPO centers, except Vridhachalam in Tamil Nadu, quite

substantial yield benefits were recorded from the use of the raised-bed system for growing the crop.

For Vridhachalam, some problems related to the proper management of the crop on beds was pointed out in the AICORPO Workshops. These evaluation trials are still being continued at AICORPO centers across the groundnut growing areas of India, as the conduct of trials and feed-back from many AICORPO centers were, until recently, very poor.

3.4 Impact of groundnut technology

ICRISAT's efforts to assist the Indian national programs in transfer of technology for groundnut production has had the desired impact. It is gratifying to note that:

- A development oriented organisation, the National Dairy Development Board (NDDB), and its subsidiaries, the State Cooperative Oilseeds Growers' Federations (SCOGFs) are fully convinced of the usefulness of the improved technology, and the importance of incorporating both the improved cultural practices and improved varieties. From 1989-90, NDDB has allocated an annual budget of about Rs. 0.4 million to each State Federation/Union for spreading the technology to groundnut farmers over a period of 5 years. Estimates of the areas to be covered by their demonstrations, and the quantity of seed of improved varieties to be handled by the different Federations during 1991-92 are given in Table 15. Under the Cooperatives, NDDB/SCOGFs have been providing the services of tractor-drawn bed makers to farmers for the preparation of the raised-beds.

- Most Departments of Agriculture are now advocating the use of various components of the improved technology, particularly use of improved

varieties, and of the raised-bed system. They continue to carry out on-farm trials at their seed farms and demonstrations in farmers' fields. The seeds multiplied on seed farms and in demonstrations are distributed to more and more farmers. The major movement of the improved seed is now from farmer to farmer.

- Scientists of the national programs (ICAR and others) are now fully convinced of the benefits of using the various components of the technology, and particularly of the raised-bed system's benefit for improving the yield of groundnut. The Annual AICORPO Workshop 1990 recommended use of the raised-bed system for growing groundnuts in the states of Andhra Pradesh, Maharashtra and Gujarat. Evaluation of the package of practices for other states of India is not yet adequate for making recommendations. However, with the results that are now coming from other states, it is most likely that the use of raised-bed systems for growing groundnut will soon be a common recommendation.

- Farmers are aware that low germinability of groundnut seed from the summer crop is due to too rapid drying of the produce after harvest in the hot sun of April and May. During on-farm trials/demonstrations we taught the extension workers and farmers how to slow down the drying of pods by heaping the uprooted plants in a circle with the pods facing inwards, preferabley under the shade of a tree or roof. Some farmers have started practicing this method at least to dry their seed stock from the summer produce. Extension workers are taking this message to farmers.

- ICAR is contemplating setting up an evaluation team for a detailed study of farmers' perceptions on adoption and non-adoption of the

technology so that these components of the technology which need administrative and monetary support are identified. Once these components are identified the necessary administrative and financial support to the technology will be given by the Government of India. The evaluation work is expected to start by August 1991.

4. PIGEONPEA

The pigeonpea on-farm trials program was initiated in the rainy season 1988 and continued for 1989. From 1989 a joint program was formulated with scientists of the national programs for conducting on-farm trials. Trials conducted during 1988-89 are listed in Table 5. In the first season at least, one trial in each state was monitored by ICRISAT staff, but in the later season the trials were monitored mainly by staff of the State Departments of Agriculture.

4.1 On-farm trials

An on-farm trial with pigeonpea had two treatments - a) an improved variety with its package of practices, and b) a common variety with its package. ICRISAT offered short-duration pigeonpeas as improved varieties, and these require a different package of practices from those suitable for conventional medium-duration pigeonpeas. Some extension workers, however, tried the short-duration pigeonpeas using the common package of practices.

The average pigeonpea yields obtained in two seasons of trials in different states are given in Table 16. In a total of 67 trials, improved varieties yielded an average 1.15 t ha^{-1} compared with an average of 0.73 t ha^{-1} from the common varieties. Cultivation of improved varieties required an extra expenditure of Rs. 2350 ha^{-1} over the normal expenditure of Rs. 3348 ha^{-1} for the common varieties. However, this expenditure provided an

extra net benefit of Rs. 800 ha^{-1}. The higher expenditure for growing short-duration pigeonpeas was largely due to the higher cost of controlling the insect pests to which short-duration pigeonpeas are normally more susceptible.

4.2 On-farm trials in summer season

ICRISAT has bred some photo-insensitive, extra-short duration pigeonpeas, which do well in the summer season. The Government of India in 1988 indicated interest in trying these pigeonpeas in the summer season, so fourteen trials/demonstrations were conducted in different states. The results of these trials/demonstrations are given in Table 17. Yield were fairly good. In Maharashtra and Tamil Nadu, yields as high as 1 t ha^{-1} were recorded. In the summer trials the pigeonpeas suffered less from insects attack than they normally do in the rainy season.

4.3 On-farm demonstrations

Some State Departments of Agriculture conducted on-farm demonstrations of short- and extra-short duration pigeonpeas in farmers' fields while continuing with on-farm trials at the seed-farms. The yield data obtained from these demonstrations are given in Table 18. The short- and extra-short duration varieties performed well in most places, often yielding more than a 1 t ha^{-1}. Use of these varieties enabled farmers to grow a subsequent postrainy season crop such as sorghum, chickpea, groundnut etc.; this is not normally possible following medium-duration varieties.

4.4 Other pigeonpea demonstrations

Some Departments of Agriculture also requested seeds of some ICRISAT medium-duration pigeonpeas resistant to diseases, especially the wilt-resistant varieties ICPL 270 and ICP 8863 ('Maruti' released in Karnataka)

and the wilt and sterility-mosaic resistant varieties ICPL 87051 and ICP 8094. These varieties were grown in demonstrations by the Departments of Agriculture. Limited data available from these demonstrations are given Table 19.

A perennial pigeonpea named by farmers as 'Japan Super' or Japan 1' gave yields in the range of 400-4575 kg ha^{-1}. Yields were particularly high when this variety was grown on fertile soils with high inputs. There is some doubt as to the identity of this material; it may be ICP 8094.

4.5 Front-line on-farm trials (ICRISAT/ICAR)

In the 'Kharif Pulses Workshop 1990' of the All India Coordinated Pulses Improvement Project (AICPIP), ICAR, the ICRISAT pigeonpea hybrid ICPH 8 was identified for release in the central zone of India (Maharashtra, Gujarat, and Madhya Pradesh). This cultivar was choosen for on-farm trials under the ICAR/ICRISAT project on transfer of technology. In a group meeting held during the workshop it was decided to conduct two on-farm trials in each of the states of Maharashtra, Gujarat and Madhya Pradesh under the leadership of senior pulse scientists of these states. Further more, it was decided to entertain any requests additional from these states for trials if seed was available. Requests were later received from Maharashtra and Gujarat.

The data received on these trials are given in Table 20. Information from two trials in Madhya Pradesh and one in Maharashtra are yet to be received. Madhya Pradesh has reported that the trials failed because of heavy rains during July-August 1990. In general, ICPH 8 gave 14.8% more yield than ICPL 87, and required relatively less investment for its cultivation. Lower susceptibility of ICPH 8 to Helicoverpa armigera as

compared with ICPL 87 was the reason for its lower cost of cultivation as it needed fewer sprays.

Besides on-farm trials of ICPH 8 and ICPL 87 in the central zone, ten on-farm trials with the Helicoverpa armigera-resistant pigeonpea ICPL 332 (released as 'Abhaya' in Andhra Pradesh in early 1990) were approved by the AICPIP Workshop for the state of Andhra Pradesh. These on-farm trials conducted by the Andhra Pradesh Agricultural University were not laid out properly and no yield data have been received on these trials.

4.6 Impact of improved pigeonpea technology

The pigeonpea on-farm trials and demonstrations have created much interest in transfer of improved technology to farmers. The following are the salient points of the impact.

- Short-duration pigeonpea ICPL 87 and ICPL 151 when first released for cultivation were not presented to farmers together with appropriate packages of practices. Our on-farm trials have educated extension workers and farmers on how to grow these varieties. Many farmers who were earlier disappointed when they tried these varieties have now resumed growing them but with appropriate packages of practices.

- The extra-short-duration pigeonpeas were tried for the first time in on-farm trials, and have created interest among extension workers and farmers. In the Vidharbha and Marathawada regions of Maharashtra, farmers identified pigeonpeas ICPL 85012, ICPL 85014 and ICPL 85030 as being better than ICPL 87 for their areas. These varieties are now being multiplied and grown in these areas. Postrainy season cultivation of these varieties is also taking place in some parts of Maharashtra and Tamil Nadu.

- Medium-duration, wilt-resistant materials like ICP 8863 (commonly grown in Karnataka), and ICPL 270, have now gone to more farmers through the on-farm trials/demonstrations. ICP 8863 is now becoming popular in the Vidharbha region of Maharashtra, and ICPL 270 in the Rayalaseema region of Andhra Pradesh. The spread of these varieties is from farmer to farmer.

- Many extension workers and farmers have improved their capacity to manage the pod-borer Helicoverpa armigera in pigeonpeas. Some have started using better pesticide application techniques. The Back-pack CDA sprayer (Fig. 3) designed by ICRISAT for effectiveness, economy, and safety in pesticide application on pigeonpea is now being sought after by farmers for general use.

- One of the perennial pigeonpeas (hopefully ICP 8094) identified basically for the agroforestry program is doing well under high input irrigated agriculture. In 1990, there were about 100 farmers in the Marathwada region of Maharashtra, who grew this pigeonpea and they obtained yields as high as 5 t ha^{-1}. Though, the actual identity of the variety is not yet clear, one must appreciate the ingenuity of farmers in growing this pigeonpea as a 'horticultural' crop.

5. CHICKPEA

The chickpea program of on-farm trials was initiated in the postrainy season of 1988 and continued for one more season. The number of on-farm trials conducted and monitored by ICRISAT during 1988-90 are listed in Table 5. ICRISAT did not ask the Departments of Agriculture to conduct on-farm trials in 1989-90, but the impact of the first season's trials was

such that a number of State Departments of Agriculture decided to take up the improved chickpea technology for on-farm demonstrations.

5.1 On-farm trials

Chickpea on-farm trials were conducted under nonirrigated and irrigated conditions. The average yields recorded in trials in different states during 1988-90 are given in Table 21. For both nonirrigated and irrigated trials, the improved varieties together with improved package of practices were found to increase yield.

Under nonirrigated trials, the extra-short-duration, wilt-resistant, kabuli variety ICCV 2 only was tried. This variety yielded 31.9% more with the improved package and 26.7% more with the common package than the common varieties. Common varieties with the improved package produced 15% more yield than with the common package. Both the improved variety and improved package together yielded 51.6% more than the common varieties with the common package.

Improved technology, that is, the improved variety and improved package of practices required an extra expenditure of Rs. 660 ha^{-1} over the normal of Rs. 3080 ha^{-1} for the common technology. This gave an extra net income of Rs. 1,665 ha^{-1} over the normal of Rs. 1,420 ha^{-1} from the common technology. The benefit from ICCV 2 was more, as it was apparently sold at some premium over the normal price of a desi cultivar.

Under irrigated conditions, improved varieties were of normal duration (120 days) and had wilt-resistance. These varieties yielded 11.6% more with the improved package and 6.7% more with the common package compared with the common varieties. The common varieties produced 15.7% more yield

with the improved package of practices. Both the improved package and improved variety together resulted in 29.2% more yield than the common package and common varieties together.

For irrigated chickpea, improved technology, that is both the improved varieties and the improved package of practices, required an extra investment of Rs. 900 ha^{-1} over the normal of Rs. 3570 ha^{-1} for the common technology. However, this extra investment provided an extra net benefit of Rs. 1,050 ha^{-1} over the normal net benefit of Rs. 3105 ha^{-1} from the common technology.

5.2 On-farm Demonstrations

Some State Departments of Agriculture, particularly those of Maharashtra and Madhya Pradesh, conducted many demonstrations in farmers' fields parallel to the on-farm trials. The yields obtained from these nonirrigated and irrigated chickpea demonstrations are compared with the districts average yields in Tables 22 and 23. The demonstrations' yields were fairly high and these provided more benefit to farmers. The benefit from short-duration kabuli cultivar ICCV-2 grown under nonirrigated situation was reported to be not only because of its higher yield but also because, seed quality fetched a premium for this cultivar over desi cultivars.

5.3 Impact of chickpea technology

Chickpea on-farm trials and demonstrations have created the desired interest in transfer of production technology to farmers. The following are some of the impacts:

- The Departments of Agriculture of Maharashtra, Andhra Pradesh, Karnataka and Gujarat are making earnest efforts in transfering the

chickpea technology to farmers. Particular efforts are being made to encourage use of the the extra-short duration wilt resistant kabuli cultivar ICCV 2 for nonirrigated conditions.

- On-farm trial data generated for ICCV 2 and ICCC 37 led to the release these varieties as 'Kranti' and 'Swetha' in Andhra Pradesh in 1990.

- Scientists of the Agricultural Universities of Maharashtra are making efforts to release chickpea varieties ICCV 5 and ICCC 37 in their state with the support of data from our on-farm trials. Efforts are being made in Karnataka to release the variety ICCV 2.

- Irrigated on-farm trials have made a distinct impact in some parts of the state of Maharashtra where water for irrigation is not a constraint. The on-farm trials have shown that farmers can obtain yields as high as 3.0 t ha^{-1} under irrigated condition. More and more farmers are now seen growing chickpea under irrigation in the Marathawada and Vidharbha regions of Maharashtra.

- The narrow-bed system of land preparation (Fig. 2) which accommodates two rows of plants per bed has been found to facilitate uniform irrigating of the crop in the black soils of Maharashtra, and the area of chickpea under this system is increasing.

- The State Departments have increased multiplication and distribution of seeds of improved chickpea varieties to farmers. More and more seed is known to be moving from farmer to farmer.

6. IDEAS AND INNOVATIONS

During the course of on-farm trials and demonstrations, various new ideas were developed and innovations made. These innovations in relation to some important aspects of the technology are described below:

6.1 Raised-bed systems

For on-farm trials, ICRISAT recommended shaping the land into broad-beds for growing the crops, except for nonirrigated chickpea, which was recommended to be grown on flat. The broad-beds, which are prepared by opening furrows (30 cm wide and 22.5 cm deep) at 1.5 m intervals accommodates 4 crop rows (spacing 30 cm) per bed. This system of growing the crop in practice was found good only when the crop was irrigated by sprinklers (fortunately this was one of the recommendations of ICRISAT's improved package). Irrigation through furrows of broad-beds often did not percolate to wet the entire bed, thus affecting the central crop rows. To tackle this problem, we modified the system for laying out the demonstrations in farmers' fields. Keeping the plant population the same as that obtained on broad-beds, we tried three systems (Fig. 2) for growing the crops depending upon the season, soil type and irrigation system available with the farmer. These were:

i) broad-bed and furrow,

ii) bed and furrow, and

iii) Narrow-bed and furrow or Ridge and furrow.

These systems are now working well with farmers. In general, farmers are invariably choosing the former two systems for the rainy season and the latter two systems for the postrainy season.

6.2 Direction of beds

The broad-bed and furrow system of growing the crops was basically developed for the management of vertisols (black soils) which normally have a problem of drainage of excess rain water causing soil erosion. Beds prepared along 0.4-0.8% slopes in black soils have given good results experimentally and also in practice. The same system tried experimentally along 0.4-0.8% slope in red soils, which normally have no problem of drainage, has not often worked. Here, it tended to drain off of rain water rather too quickly, causing relatively more soil erosion. However, the system tried in practice across the slope in red soils has worked well for conserving moisture. Directions for making beds in black and red soils are outlined in Fig. 4.

6.3 Seed dibbling/drilling

In the beginning, we recommended dibbling the seeds for sowing. Our intention was to get an adequate plant population which was thought to be a problem when using common seeding methods, like dropping the seeds behind a plow, drilling the seed with a seed drill etc. However, dibbling as expected proved uneconomical and often impossible due to lack of labour in many situations. During on-farm trials, we critically studied sowing on beds using a seed drill, and found that, if done properly the seed-drilling gave good results. For groundnut, seed drilling an individual row or two rows together using a common seed bowl employing 2-4 labourers has given good results (Fig. 5). For pigeonpea and chickpea, which have hard seed coats, sowing 4 rows together using a common seed-bowl was as good as single row sowing (Fig. 5). The skilled labourers available in most villages were capable of doing a fairly good job in spacing the seeds in rows and also in using an optimum quantity of seed through a seed drill.

During on-farm trials of groundnut in Tamil Nadu, we encountered a fast dibbling method for sowing called the 'punch and drop method' practiced by some farmers in sandy and sandy-loamy soils (Fig. 7). This system was effective in getting the seed sown at the proper depth and in the right quantity. In this system small holes are punched in the soil with a small spade at intervals of about 10 cm along the seeding rows and one seed is dropped in each of these holes simultaneously by skilled female labourers. This system can be taken to other areas of India which have a similar soil type.

6.4 Implements for preparing beds

The raised-bed system (initially broad-bed) was the major component of improved technology for growing the crops in on-farm trials as well as demonstrations. In early trials on seed farms bullock-drawn wheeled-tool-carriers like the Tropicultor (Fig. 8) and Agribar (Fig. 9) were used for preparing beds. But in later on-farm trials these implements were not commonly available and we had to use local implements for preparing beds. During this process, together with extension workers and farmers we used a ridger plough, and also developed and modified some local implements available with farmers to prepare raised beds. Some of these implements used, developed and modified to make beds are shown in Fig. 10. Among the various bullock drawn implements tested on-farm, the agribar which is a light, multipurpose wheeled-tool carrier suitable for use with average sized bullocks appeared to be the best not only for the preparation of beds but also for many other field operations including sowing. The tropicultor proved too heavy for most bullocks.

Tractors, available to some farmers, have rigid attachments for ploughing, harrowing and intercultivation implements. For using tractors to prepare raised-beds we developed a simple tractor drawn raised-bed maker which consists of a tool-bar, two ridger ploughs, and a bed shaping chain (Fig. 11). This BBF maker is liked by some farmers who have tractors, and by farmers who are organised in cooperative societies. The State Cooperative Oilseeds Growers' Federations are now providing the services of tractors to farmers for preparing raised-beds for their crops. Simple seeding attachments have also been developed for the tractor drawn tool bar. These developments are expected to take the technology to farmers at a faster rate.

7. PUBLICATIONS

7.1. Papers

1. Amin, P.W., Jain, K.C., Kumar Rao, J.V.D.K. and Pawar, C.S. 1989. ICRISAT's experience in the introduction of improved groundnut technology in India. Pages 61-65 in summary proceedings of the Regional Legumes Network Coordinators' Meeting. ICRISAT, Patancheru, P.O., A.P. 502 324, India, ICRISAT.

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7.2. Video-film

'Groundnut Production Technology for High Yields' (1991). This video-film of 33 minutes gives complete idea about the improved production technology for groundnut.

Table 1. Package of practices for groundnut on-farm trials.

Field operation/input	Improved package	Common package (general)
Land preparation	Ploughing, clod crushing and harrowing to obtain fine tilth.	Deep ploughing once, light ploughing twice, harrowing twice
Fertilisers ha^{-1} (basal)	FYM = 10 t Am.sulp. = 100 kg SSP = 300-400 kg MOP = 0-80 kg if reqd. $ZnSO_4$ = 20 kg	FYM = 5-12 t DAP = 100 kg MOP = 100 kg $ZnSO_4$ = 20 kg
Sowing date	June with monsoon/November	June/November,December
Seed bed	Broad bed and furrow	Flat bed
Variety	ICGS 11, ICGS 21, ICGS 37, ICGS 44, ICGS 65, ICGS 76, FDRS 4 or FDRS 10.	TMV 2, TMV 7, JL 24, SB XI, CO 2, S 206, KRG 1, GG 2, VRI 2, AK 12-24,
Seed rate	120 kg ha^{-1}	125-150 kg ha^{-1}
Spacing	30 X 10 cm	30 X 10 or 45 X 10 cm
Herbicide	Stomp 3.5 l ha^{-1}	Nil
Seed dressing	Thiram 3g kg^{-1} seed	Thiram 2g kg^{-1} seed
Sowing	Dibbling	Behind country plough/ Country seed drill
Gypsum	400 kg ha^{-1} at flowering	200 kg ha^{-1}
Plant Protection	Bavistin 250g + Dithane M-45 1 kg ha^{-1} for leafspot and rust, if required. Dimethoate 660ml ha^{-1} for thrips, jassids and leafminer, 15 days after emergence. Monocrotophos 1L or Endosulfan 2L/ha for Spodoptera, Heliothis and other caterpillars.	Need base
Nutrients	FeSO4 2.5 kg + Urea 5 kg ha^{-1}, two sprays, 30 and 50 days after emergence in 500 L. water	
Irrigations	Sprinkler/furrow	Flooding
Harvest	With maturity	With maturity

Table 2. Package of practices for pigeonpea on-farm trials.

Field operation/input	Short-duration pigeonpea	Medium-duration pigeonpea
Land preparation	Ploughing, clod crushing and harrowing to obtain fine tilth	Two ploughings and two harrowings.
Fertilizers ha^{-1} (basal)	FYM - 10 t DAP = 100 kg SSP = 100 kg $ZnSO_4$ = 20 kg (only in Zn deficient soils)	FYM = 10 t N = 20 kg as Urea P_2O_5 = 100 kg
Top dressing by placement in soil	Urea = 50 kg at the time of flowering	
Ratoon crop	DAP = 50 kg after eatch harvest	
Sowing date	2nd week of June	In June With rains
Seed bed	Broad bed & furrow	Flat
Variety	ICPL 87,ICPL 151,ICPL 85012, ICPL 85014, ICPL 84023,ICPL 85030.	LRG 30,UPAS 120,Manak, AL 15,C 11,TTB 7
Seed rate	35 kg ha^{-1}	10-15 kg ha^{-1}
Spacing	30 X 10 cm	45-100 X 20 cm
Weed control	Stomp 3.5 l ha^{-1}	Hand weeding
Seed dressing	Benlate T 3g kg^{-1} seed	Thiram 3g kg^{-1} seed
Sowing	Hand dibbling/by seed drill	Drilling
Plant protection	Lanate 20 EC @ 2 l ha^{-1} for Helicoverpa control. First spray at flower opening stage. Subsequent sprays at an interval of 15-20 days. Foliar spray of Ridomyl M-Z 72 WDP @ 1 kg ha^{-1} for Phytophthora blight, if required.	As required
Irrigation (Protective)	Sprinkler/Furrow. Fist irrigation at sowing. Subsequent irrigations as needed. Give irrigation soon after each harvest followed by irrigations as needed.	Check basin
Harvest	Pick pods 110-120 days after sowing. Fertilize and irrigate. Follow the same procedure for second and third flush when mature.	As per common recommendation

Table 3. Package of practices for chickpea on-farm trials.

Field operation/input	Improved package	Common package (general)
Land preparation	Two ploughings and one harrowing.	Two ploughings and one harrowing.
Fertilizers ha^{-1} (basal)	FYM = 10 t DAP = 100 kg $ZnSO_4$ = 10 kg BHC/Aldrin dust = 25 kg if termites are a problem	FYM = 5 t N = 20 kg as Urea DAP = 100 kg
Sowing date	1-2 week October	15 October-15 November
Seed bed	Broad bed and furrow for irrigated and flat bed for nonirrigated crop	Flat-bed
Variety	ICCC 42, ICCC 37, ICCV 6, ICCV 5, ICCV 2, ICCV 10	Annigeri, Chaffa, BDN-9, CO 1 C 235, JG-315, K 850, Radhey Ujjain 21
Seed rate	70-80 kg ha^{-1}	60-100 kg ha^{-1}
Spacing	30 X 10 cm	45 X 10-15 cm
Weed control	Preemergence stomp 3.0 l ha^{-1}. and/or Hand weeding during the season as required	Hand weeding during the season
Seed dressing	Benlate + thiram(1:1)3g kg^{-1} seed	Thiram 2g kg^{-1} seed
Sowing	Hand dibbling/seed drill	Seed drill
Plant protection	For pod borer control apply either Endosulfan 4%, Quinalphos 1.5% or Methyl parathion 2% dust @ 20-25 kg ha^{-1}. OR Spray Endosulfan 35 EC, Quinalphos 25 EC @ 2 l ha^{-1}, Monocrotophos 36 EC_{-1} or Methylparathion 50 EC @ 1 l ha^{-1}. First spray should be given at flowering and then at 10-15 day intervals, as reqd.	As required
Ferrous sulphate	Apply one spray of ferrous sulphate(commercial) @ 2.5 kg ha^{-1} in 500 lts. of water at flowering, only after heavy rain or with yellowing in plants.	
Irrigation	Pre- or post-sowing irrigation followed by the second irrigation at flowering and the third a month late.	As per common recommendation
Harvest	As soon as the crop dries up	When the crop dries up

Table 4. Groundnut, pigeonpea and chickpea varieties used in on-farm trials, 1987-1990.

Crop	Improved varieties	Common varieties
Groundnut	ICGS 11, ICGS 44, ICGS 76, ICG(FDRS) 4, ICG(FDRS) 10, ICGS 37, ICGS 21, ICGS 65, ICGS 1, ICGS 5	JL 24, TMV 2, TMV 7, AK-12-24, VRI 2, CO 2, S 206, KRG 1, SB XI, GG 2, Spanish improved, Chandra, Kadiri 3, NC 362, Tijja
Pigeonpea	ICPL 87, ICPL 151, ICPL 85012, ICPL 85010, ICPL 84014, ICPL 84023, ICPL 85030	LRG 30, UPAS 120, Manak, AL 15, BDN 2, TTB 7
Chickpea	ICCV 2, ICCV 5, ICCV 6 (Kabuli), ICCC 37, ICCC 42 (Desi) ICCV 10 (presently added)	Annigeri, Ujjain 21, JG 315, Chaffa, BDN-9-3, Phule G5, H 208, C 235, K 850, ICCC 4, CO 3

Table 5. Number of groundnut, pigeonpea and chickpea on-farm trials conducted and monitored by ICRISAT Departments of Agriculture (DOA), 1987-1990.

		No. of trials conducted	ICRISAT monitored	DOA monitored
Groundnut				
Rainy season	1987	13	13	-
..	1988	27	15	12
..	1989	27	5	22
..	1990	16	3	13
Postrainy season	1987-88	14	14	-
..	1988-89	23	17	6
..	1989-90	21	5	16
Pigeonpea				
Rainy season	1988	29	16	13
..	1989	38	-	38
Summer season	1988-89	14	8	6
Chickpea				
Postrainy season	1988-89			
Nonirrigated		21	8	13
Irrigated		34	19	15
Postrainy season	1989-90			
Nonirrigated		6	-	6
Irrigated		6	-	6

Table 6. Average dry pod yields of groundnut grown according to improved and common packages of practices in different states of India, 1987-90.

State	No. of Trials	Pod Yield (t ha^{-1})			
		Improved package		Common package	
		Improved variety	Common variety	Improved variety	Common variety
Rainy season					
Andhra Pradesh	16	1.44	0.99	1.29	0.92
Karnataka	23	1.88	1.39	1.47	0.98
Tamil Nadu	7	2.50	2.11	2.14	1.80
Gujarat	16	1.18	1.33	1.11	1.07
Maharashtra	14	2.22	1.17	1.36	1.33
Orissa	4	2.34	1.09	1.97	0.93
Madhya Pradesh	2	2.32	2.16	1.72	1.63
Uttar Pradesh	1	1.80	1.50	1.18	1.02
	83				
Mean		1.96	1.47	1.53	1.21
Postrainy season					
Andhra Pradesh	13	2.87	2.25	2.28	1.92
Karnataka	11	2.70	1.95	2.16	1.42
Tamil Nadu	9	2.62	2.38	2.48	2.18
Gujarat	6	2.01	1.57	1.40	1.33
Maharashtra	15	3.49	1.97	2.56	1.74
Orissa	4	3.51	2.65	2.71	2.12
	58				
Mean		2.87	2.13	2.26	1.79

Yield benefit

	Rainy season	Postrainy season
By adoption of Improved package alone	: 21.5	19.0
By adoption of Improved variety alone	: 26.4	26.2
By adoption of both the Improved package + Improved variety	: 60.9	60.3

Extra cost and benefit (Rs. ha^{-1})

Extra production cost for technology	Rs. 1590 (N:6220)	1420 (N:6990)
Extra net benefit from technology	Rs. 4410 (N:3460)	7220 (N:7330)

N: Normal cost or benefit

Note: Average selling price of groundnut pod for seven seasons Rs. 8000 t^{-1}

Table 7. Percent yield benefit recorded from improved groundnut technology trials conducted in different states of India, 1987-90.

	Year				
	1987	1988	1989	1990	Average
Rainy season					
Yield benefit from improved package alone	*	21.3	24.7	23.2	23.1 (± 0.80)
Yield benefit from improved variety alone	*	27.8	25.8	51.5	35.0 (± 6.74)
Yield benefit from both the Improved package + Improved variety	68.4	62.0	49.4	61.6	60.3 (± 3.43)
	1987-88	1988-89	1989-90	1990-91	
Postrainy season					
Yield benefit from Improved package alone	18.2	19.2	16.9	-	18.1 (± 0.54)
Yield benefit from Improved variety alone	31.1	37.8	16.9	-	28.6 (± 5.0)
Yield benefit from both the Improved package + Improved variety	69.8	66.6	47.9	-	61.4 (± 5.58)

* Only two treatments were practiced

- data yet to be obtained

Table 8. Average dry pod yields of groundnut grown according to improved and common packages of practices in farmers' fields by the Karnataka Co-operative Oilseeds Growers' Federation, Karnataka, 1989-90.

Season/ Location	No.of Partici-pants	Area in ha	Dry pod yield (t ha^{-1})			
			Improved package		Common package	
			Improved variety	Common variety	Improved variety	Common variety
Rainy season 1989						
Raichur	63	45	1.65	1.28	1.42	0.86
Manvi	126	70	1.59	1.27	1.26	0.89
Ballary	78	55	1.88	1.43	1.57	0.94
Challakere	46	30	1.54	1.27	1.22	0.92
Kustagi	21	19	1.76	1.44	1.30	0.82
Shorapur	52	32	1.02	0.96	0.99	0.94
Postrainy season 1989-90						
Raichur	69	60	2.11	1.80	1.78	1.18
Manvi	65	63	2.03	1.79	1.66	1.07
Kustagi	22	15	1.87	1.67	1.47	0.87
Ballary	108	66	2.11	1.77	1.61	1.01
Shorapur	79	53	2.15	2.02	1.61	1.00
Manvi	321	55	1.99	1.54	1.65	1.42
Rainy season 1990						
Shorapur	53	33	2.00	1.59	1.63	0.90
Koppal	60	35	1.66	1.61	1.64	0.91
Hubli	3	1.2	1.71	1.45	1.59	1.52
Gadag	14	32	1.51	1.15	1.19	1.03
Bijapur	13	39	1.19	1.15	1.21	1.17
Chellakeri	287	39	1.59	1.57	1.33	1.11
	1480	762.2				
Mean			1.74	1.49	1.45	1.03

Yield benefits

By adoption of improved package alone	44.7%
By adoption of improved variety alone	40.8%
By adoption of Improved variety + Improved package	68.9%

Extra cost and benefits Rs. ha^{-1}

Extra production cost for technology	Rs. 970 (N: 4130)
Extra net benefit from technology	Rs. 6130 (N: 6170)

N: Normal cost or benefit.
Note: Average selling price of groundnut pod for 3 seasons Rs. 10,000 t^{-1}

Table 9. Average dry pod yields of groundnut grown according to improved and common packages of practices in farmers fields by the Tamil Nadu Co-operative Oilseeds Growers' Federation, Tamil Nadu, 1989-90.

Season/Location	No. of participants	Area covered ha	Dry Pod yield (t ha^{-1}) Improved package Common variety	Dry Pod yield (t ha^{-1}) Common package Common variety
Postrainy season 1988-89				
Cheyyar	41	16	1.76	-
Rainy season 1989				
Vridhachalam	10	4	1.25	0.85
Postrainy season 1989-90				
Vridhachalam	20	8	1.68	-
Cheyyar	9	4	1.66	1.20
Tiruvannamali	10	4	2.59	-
Rainy season 1990				
Vridhachalam	10	4	1.18	0.94
Tiruvannamalai	5	2	1.60	1.10
Cheyyar	5	2	1.79	0.90
	110	44		
Mean			1.69	1.00

Yield benefit

By adoption of improved package alone 69%

Extra cost and benefit (Rs. ha^{-1})

Extra cost for technology Rs. 1062 (N: 4370)

Extra net benefit from technology Rs. 5150 (N: 4630)

N: Normal cost or benefit

Note: Average selling price of groundnut pods for 4 seasons Rs. 9000 t.

Table 10. Dry pod yields of groundnut grown according to improved and common packages of practices in farmer fields by the Maharashtra State Co-operative Oilseeds Growers' Federation, Maharashtra 1989-90.

Season/ Location	No. of partic- pants	Area covered in ha	Dry pod yield (t ha^{-1}) Improved package	Common package
Postrainy season 1989-90				
Dharangaon	1	0.4	2.25	1.50
Nimbhli	1	0.4	2.27	2.00
Chincholi	1	0.4	1.87	1.25
Anvi	1	0.4	1.20	0.90
Shirdane	1	0.4	1.33	1.10
Sarve	1	0.4	1.24	1.03
Nampur	1	0.4	1.82	1.00
Golegaon	1	0.4	2.20	1.62
Rainy season 1990				
Bhilkheda	1	0.4	1.16	0.79
Wadri	1	0.4	1.02	0.81
Chalisgaon	1	0.4	1.30	1.00
Banne	1	0.4	1.20	1.12
	12	4.8		
Mean			1.57	1.18

Yield benefit

By adoption of improved package 33%

Extra cost and benefit (Rs. ha^{-1})

Extra cost for technology	Rs. 880	(N:5830)
Extra net benifit from technology	Rs. 3020	(N:5970)

N: Normal cost or benefit

Note: Average selling price of groundnut pods for 2 seasons Rs. 10,000 t^{-1}.

Table 11. Average dry pod yields groundnut grown according to improved and common packages of practices in farmers' fields by the Gujarat Cooperative Oilseeds Growers' Federation, Gujarat, 1989-90.

Season/ Location	No. of parti-cipants	Area in ha	Dry pod yield (t ha^{-1})	
			Improved package	Common package
			Improved variety	Common variety
Rainy season 1989				
Junagadh	6	1.2	1.30	1.08
Jamnagar	2	0.4	0.45	0.45
Postrainy season 1989-90				
Junagadh	9	3.6	2.09	1.15
Bharuch	10	2.0	0.89	-
Jamnagar	5	2.0	2.50	1.65
Rainy season 1990				
Jamnagar	1	0.4	0.70	0.65
	33	9.6		
Mean			1.32	1.00

Yield benefit

By adoption of Improved package + Improved variety: 32%

Extra cost and benefit (Rs. ha^{-1})

Extra cost for technology	Rs.	1160 (N: 4020)
Extra net benefit from technology	Rs.	2040 (N: 5980)

N: Normal cost or benefit

Note: Average selling price of groundnut pod for 3 seasons Rs. 10,000 t^{-1}.

Table 12. Average dry pod yield of groundnut grown according to the improved and common packages of practice by the Andhra Pradesh State Cooperative Oilseeds Growers' Federation, Andhra Pradesh 1987-90.

Seasons/ Locations	No. of parti- cipants	Area covered in ha	Dry pod yield (t ha^{-1}) Improved* package	Common* package
Postrainy season 1987-88				
Mahabubnagar	6	2.4	1.78	1.55
Rainy season 1988				
Mahabubnagar	4	1.6	1.23	1.06
Postrainy season 1988				
Mahabubnagar	10	4	1.99	1.75
Postrainy season 1989-90				
Mahabubnagar	2	0.8	1.16	1.13
Rainy season 1990				
Mahabubnagar	2	0.8	1.51	1.19
Khammam	3	1.2	1.65	1.21
Chittor	3	1.2	1.74	-
Cuddapah	2	0.8	1.86	-
Ongole	1	0.4	0.82	-
Anantapur	4	1.6	1.38	0.97
	37	14.8		
Mean			1.51	1.26

* 50% trials were with improved varieties

Yield benefit

By adoption of Improved package 19.8%

Table 13. Pod yields of groundnut in demonstrations conducted by Departments of Agriculture, 1987-90.

State/District	Varieties	No. of demon-strations	Average yield ($t\ ha^{-1}$)	District* Average yield ($t\ ha^{-1}$)
Rainy season				
Andhra Pradesh				
Anantapur	ICGS 11, ICGS 44	3	1.93 (± 0.34)	0.56
Chittor	,, ,,	2	1.86 (± 0.47)	0.57
Maharashtra				
Nagpur	ICGS 44, ICGS 11, ICGS 21	3	2.67 (± 0.25)	0.96
Parbhani	,, ,, ,,	7	0.79 (± 0.15)	0.73
Tamil Nadu				
South Arcot	ICGS 44, VRI 2	7	1.75 (± 0.15)	0.65
Karnataka				
Raichur	ICGS 44, ICGS 11, ICGS (FDRS) 10	25	0.89 (± 0.11)	0.34
Gujarat				
Jamnagar	ICGS 44, ICGS 11	2	0.55 (± 0.12)	0.49
Junagadh	,, ,,	5	1.45 (± 0.23)	0.69
Postrainy season				
Andhra Pradesh				
Warangal	ICGS 44, ICGS 11	3	2.89 (± 0.32)	1.17
West Godavari	,, ,,	2	3.40 (± 0.43)	1.80
Vishakapatnam	ICGS 44, ICGS 21	2	3.09 (± 0.45)	1.46
Cuddapah	ICGS 44, ICGS 11	2	1.90 (± 0.25)	1.29
Nalgonda	,, ,,	1	2.67 -	1.14
Maharashtra				
Parbhani	ICGS 44, ICGS 11, ICGS 21	139	1.93 (± 0.08)	-
Amraoti	ICGS 21	25	1.25 (± 0.11)	-
Tamil Nadu				
South Arcot	VRI 2	9	1.66 (± 0.12)	1.40
Orissa				
Puri	ICGS 44	2	2.43 (± 0.26)	1.34
Gujarat				
Junagadh	ICGS 11, ICGS 44	4	1.62 (± 0.11)	0.69
Mean			1.93 (± 0.23)	0.95 (± 0.09)

* from Agricultural Situation in India 1985.

Table 14a. Dry pod yield of groundnut in trials grown on raised-bed and flat-bed systems of land preparation, AICORPO/ICRISAT, postrainy season 1989-90.

	Pod yield (t ha^{-1})							
	Maharashtra		Gujarat		Andhra Pradesh		Tamil Nadu	
	Jalgaon		GAU, Junagadh		Jagtial		Vridhachalam	
System	ICGS 11	SB XI	ICGS 44	GG 2	ICGS 11	K 3	ICGS 44	VRI 2
Flat-bed	3.00	2.75	1.61	1.66	3.92	3.87	1.91	2.38
Raised-bed	3.50	3.25	1.99	1.99	4.78	3.56	1.81	1.93
Percent yield increase over flat-bed	16.7	18.2	23.6	19.9	21.9	-8.7	-5.5	-23.3

Table 14b. Dry pod yield of groundnut in trials grown on raised-bed and flat-bed systems of land preparation, AICORPO/ICRISAT, rainy season 1990.

	Pod yield (t ha^{-1})							
	Maharashtra				Madhya Pradesh	Tamil Nadu		Andhra Pradesh
	Jalgaon	Latur (ORS)	Latur	Latur	Khargone	Vridhachalam		Palem
System	JL 24	JL 24	Girnar-1	Girnar-1	JL 24	ICGS 44	VRI 2	JL 24
Flat-bed	1.15	1.00	0.85	0.80	0.83	0.27	0.57	1.00
Raised-bed	1.35	1.10	0.90	0.85	1.08	0.31	0.37	1.25
Percent yield increase over flat-bed	17.4	10.0	5.9	6.2	30.1	14.8	-54.0	25.0

Complete data have been received only from five of 15 locations.

Table 15. Estimates of the area to be covered under raised-bed system of land preparation, and of the recovery and distribution of the seeds of improved varieties by the State Cooperative Oilseeds Growers' Federations, 1991-92.

Federations	Area in hectares to be covered under raised-beds		Amount of seed of improved varieties distributed in postrainy season 1990-91 (t)	Expected recovery and distribution of seed of improved varieties	
	Rainy season 1991	Postrainy season 1991-92		Rainy season 1991 (t)	Postrainy season 1991-92 (t)
KOF	4500	4500	91	200	500
TANCOF	300	100	5	10	15
MAHAFED	300	300	10	50	300
APOILFED	150	300	10	65	300
GROFED	175	175	10	150	300
OROILFED	50	50	1	10	10

Table 16. Average grain yield of short-duration pigeonpea grown according to improved and common packages in different states of India, rainy season 1988-1989.

State	No. of Trials	Grain yield (t ha^{-1})			
		Improved package		Common package	
		Improved* variety	Common variety	Improved* variety	Common variety
Andhra Pradesh	8	0.96	-[1]	-	0.80
Karnataka	7	1.15	-	0.46	0.16
Tamil Nadu	2	1.44	-	0.49	-
Orissa	3	1.60	-	-	1.42
Gujarat	3	0.72	-	-	0.57
Madhya Pradesh	8	1.47	-	1.06	-
Maharashtra	29	1.30	-	0.93	-
Uttar Pradesh	4	0.96	-	-	0.74
Rajasthan	3	0.77	-	-	0.71
	67				
Mean		1.15	-	0.73	0.73

* yield from two flushes of flowers.
1 variety or package not tested.

Yield benefit

By adoption of short-duration pigeonpea + Technology 57.52

Extra cost and benefit (Rs. ha^{-1})

Extra cost for technology	Rs. 2350 (N: 3348)
Extra net benefit from technology	Rs. 800 (N: 2127)

N: Normal cost or benefit

Note: Average selling price of pigeonpea grains for 2 seasons Rs. 7500 t^{-1}.

Table 1.. Grain yield of extra-short-duration pigeonpea crops at 14 locations in seven states of India, postrainy season 1988/89.

State and locations	Sowing date	Grain yield (t ha^{-1})				
		ICPL 85014	ICPL 85030	ICPL 84023	ICPL 85010	ICPL 151
Andhra Pradesh						
Tangadencha	13 Jan	0.74	-[1]	-	-	-
Gujarat						
Nadiad	18 Jan	0.80	-	-	-	-
Karnataka						
Devihosur	23 Jan	0.52	-	-	-	-
Tamil Nadu						
Shivalingapatti	24 Dec	0.98	-	-	-	-
Kottur	18 Jan	0.94	0.85	-	-	-
Rajadani	29 Dec	0.95	1.03	-	-	-
Tappakundi	3 Jan	0.96	0.77	-	-	-
Kamatchipuram	19 Jan	0.64	0.60	-	-	-
Maharashtra						
Parbhani	22 Dec	0.60	-	-	-	0.67
Kidaj	20 Jan	1.00	-	1.00	1.33	1.05
Niwali	6 Feb	0.65	-	-	-	-
Bhogaon	29 Jan	0.60	-	-	-	-
Orissa						
Sakhigopal	10 Jan	0.63	-	0.92	0.63	0.46
Madhya Pradesh						
Bhikangaon	8 Jan	-	-	0.58	0.28	0.33
Mean		0.77	0.81	0.83	0.75	0.69

1.--Varieties not tested

Table 18. Grain yields of short-duration pigeonpeas in demonstrations conducted by Departments of Agriculture, 1988-90.

State/District	Varieties	No. of demonstrations	Average yield ($t\ ha^{-1}$)	District* Average yield ($t\ ha^{-1}$)
Maharashtra				
Parbhani	ICPL 151, ICPL 85012, ICPL 85014	16	1.23 (± 0.13)	0.70
Nagpur	ICPL 85030, ICPL 85012, ICPL 87	3	1.34 (± 0.25)	0.66
Akola	ICPL 85014, ICPL 85012, ICPL 85030	4	1.12 (± 0.18)	0.68
Buldana	ICPL 85014	1	0.73 -	0.63
Madhya Pradesh				
Betul	ICPL 85014, ICPL 87, 84023	6	1.55 (± 0.14)	0.67
Sehore	ICPL 87, ICPL 84023	2	0.85 (± 0.06)	0.73
Raisen	ICPL 87, ICPL 85014	2	0.90 (± 0.04)	0.76
Vidisha	ICPL 87, ICPL 85014	2	1.17 (± 0.08)	0.66
Khargone	ICPL 85014, ICPL 87	3	1.96 (± 0.05)	0.41
Dhar	ICPL 87	2	2.45 (± 0.39)	0.57
Morena	ICPL 87	4	1.73 (± 0.13)	0.99
Karnataka				
Bangalore	ICPL 87	1	0.79 -	0.47
Raichur	ICPL 87	1	1.20 -	0.18
Gujarat				
Kheda	ICPL 87, ICPL 85014	4	1.93 (± 0.02)	0.75
Amreli	ICPL 87, ICPL 85014	3	0.97 (± 0.02)	-
Mehsana	ICPL 85014	10	1.09 (± 0.10)	0.94
Sabarkanta	ICPL 87	1	1.00 -	0.72
Mean			1.29 (± 0.12)	0.66 (±0.04)

* from Agricultural Situation in India 1985.

Table 19. Grain yields of some medium- and long-duration pigeonpeas in demonstrations conducted by Departments of Agriculture, 1988-90.

State/District	Variety	No. of demonstrations	Average yield (t ha^{-1})	District* Average yield (t ha^{-1})
Andhra Pradesh	ICPL 270 (160-170 days)			
Kurnool		9	0.81 (± 0.06)	0.26
Maharashtra				
Yavatmal	,,	1	1.33 -	0.81
Buldana	,,	1	0.76 -	0.63
Madhya Pradesh				
Sehore	,,	2	1.04 (± 0.12)	0.73
Maharashtra	ICPL 8863 (150 days)			
Yavatmal	,,	1	1.33 -	0.81
Akola	,,	5	0.91 (± 0.08)	0.68
Buldana	,,	7	0.98 (± 0.09)	0.63
Maharashtra	ICPL 87051 (150-160 days)			
Nagpur	,,	1	1.50 -	0.66
Parbhani	,,	4	1.19 (± 0.24)	0.70
Akola	,,	1	0.94 -	0.68
Madhya Pradesh				
Raisen	,,	2	1.24 (± 0.01)	0.76
Vidisha	,,	2	0.71 (± 0.05)	0.66
Maharashtra	ICP 8094 (>210 days perennial)			
Aurangabad	,,	39	1.41 (± 0.14)	0.41
Mean			1.09 (± 0.10)	0.65 (± 0.04)

* From Agriculture situation in India 1987.

Table 20. Grain yields and costs of cultivation of pigeonpea ICPH 8 X ICPL 87 trials, ICRISAT/AICPIP, rainy season 1990.

Location	Grain yield (t ha^{-1})				Cost of cultivation (Rs' 000 ha^{-1})	
	ICPH 8		ICPL 87		ICPH 8	ICPL 87
Maharashtra						
Sarso (TSF)$	1.14		0.92		-	-
Aurangabad (TSF)	1.33		0.86		6.29	6.72
Partur (TSF)	3.20		3.00		5.94	5.94
Aurangabad (WALMI)	1.18		1.04		-	-
Gujarat						
Gandhinagar$	1.00	(3.46)*	0.63	(0.41)*	-	-
Mehsana$	0.33	(5.40)*	0.22	(5.10)	-	-
Rabarika (Amreli)	1.02	-	1.01	-	-	-
Chanch (Amreli)	1.05	-	1.06	-	-	-
Motasakaria (Amreli)	0.94	-	0.95	-	-	-
Mean	1.24	(4.43)*	1.08	(2.75)*	6.11	6.33

* Figures in parentheses refer to the green pod yields taken in the trials.

$ Trials closely monitored by scientists.

Note: The data of trials allocoated to Madhya Pradesh are not yet received. The trials are reported to have failed because of heavy rains.

Yield benefit from ICPH 8 over ICPL 87 = 14.8%

Table 21. Average grain yields of chickpea grown according to improved and common package of practices under non-irrigated and irrigated conditions in different states of India, postrainy seasons 1988-90.

State	No. of Trials	Grain yield (t ha^{-1})			
		Improved package		Common package	
		Improved variety	Common variety	Improved variety	Common variety
Non-irrigated					
Andhra Pradesh	5	0.53	0.28	0.68	0.35
Karnataka	9	0.78	0.76	0.75	0.72
Tamil Nadu	2	0.71	0.32	0.50	0.23
Orissa	1	1.01	0.73	0.82	0.58
Gujarat	1	0.72	0.82	0.65	0.72
Madhya Pradesh	4	1.02	0.88	0.73	0.76
Maharashtra	4	0.74	0.88	0.60	0.66
Uttar Pradesh	1	1.75	0.87	1.38	0.82
	27				
Mean		0.91	0.69	0.76	0.60
Irrigated					
Andhra Pradesh	5	0.64	0.61	0.59	0.43
Karnataka	10	0.92	0.95	0.95	1.10
Tamil Nadu	1	0.40	0.21	0.20	0.12
Orissa	1	1.73	1.11	0.99	0.45
Gujarat	3	1.20	1.31	1.05	1.15
Madhya Pradesh	3	1.32	1.36	0.93	1.09
Maharashtra	14	2.14	1.98	1.81	1.67
Rajasthan	2	0.44	0.23	0.43	0.61
Uttar Pradesh	1	1.59	1.51	1.59	1.37
	40				
Mean		1.15	1.03	0.95	0.89

Yield benefit

		Nonirrigated	Irrigated
By adoption of Improved package alone	%	15.0	15.7
By adoption of Improved variety alone	%	26.6	6.7
By adoption of both the Improved package + Improved variety	%	51.6	29.2

Extra cost and benefit (Rs. ha^{-1})

Extra cost for technology	Rs. 660 (N: 3080)	900 (N: 3570)
Extra net benefit from technology	Rs. 1665 (N: 1420)	1050 (N: 3105)

N: Normal cost or benefit

Note: Average selling price of chickpea grains for two seasons Rs. 7500 t^{-1}.

Table 22. Grain yields of nonirrigated chickpea (variety: ICCV 2) in demonstrations conducted by Departments of Agriculture, 1988-1990.

State/District	No. of demonstrations	Average yield ($t\ ha^{-1}$)	District* Average yield ($t\ ha^{-1}$)
Andhra Pradesh			
Kurnool	2	0.64 (± 0.13)	0.42
Guntur	1	0.70 -	0.60
Karnataka			
Belgaon	2	0.58 (± 0.11)	0.25
Dharwad	1	0.54 -	0.11
Maharashtra			
Parbhani	5	0.96 (± 0.05)	0.36
Akola	5	1.29 (± 0.22)	0.29
Amraoti	5	0.82 (± 0.06)	0.30
Yavatmal	5	1.24 (± 0.36)	0.43
Warda	5	0.89 (± 0.08)	0.36
Nagpur	10	1.08 (± 0.17)	0.32
Buldana	5	0.89 (± 0.13)	0.35
Orissa			
Keonjhar	1	1.01 -	0.53
Madhya Pradesh			
Guna	39	1.00 (± 0.06)	0.74
Dhar	1	0.90 -	0.24
Mean		0.90 (± 0.14)	0.38 (± 0.04)

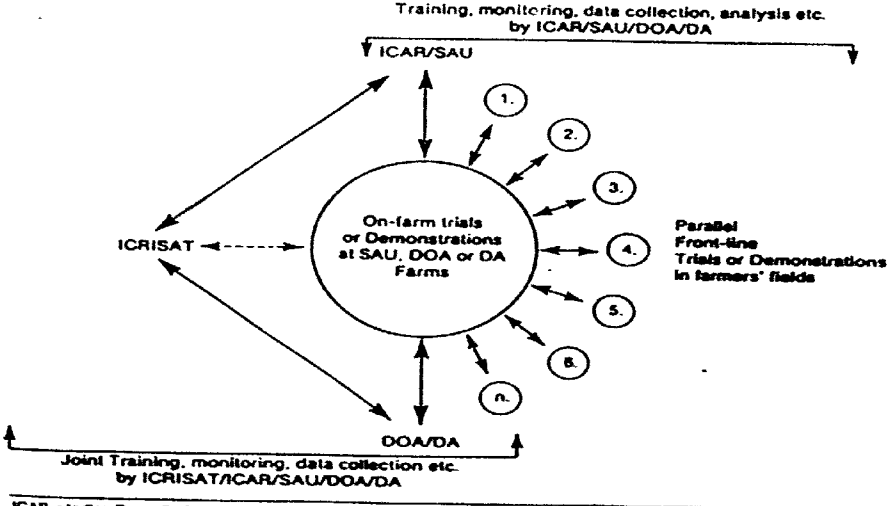
* from Agricultural Situation in India, 1987

Table 23. Grain yields of irrigated chickpeas in demonstrations conducted by Departments of Agriculture, 1988-90.

State/District	Varieties	No. of demonstrations	Average yield (t ha^{-1})	District* Average yield (t ha^{-1})
Andhra Pradesh				
Kurnool	ICCC 37	3	0.83 (± 0.30)	0.42
Karnataka				
Belgaon	ICCC 37	2	0.90 (± 0.17)	0.25
Bijapur	,,	2	1.12 (± 0.16)	0.14
Maharashtra				
Nasik	ICCC 37	1	1.65 -	0.33
Parbhani	ICCC 37, ICCV 2 ICCV 6, ICCC 42	20	1.80 (± 0.17)	0.36
Gujarat				
Panchmahal	ICCC 37	1	1.73 -	0.65
Rajasthan				
Bundi	ICCV 6	3	0.76 (± 0.20)	0.78
Madhya Pradesh				
Dhar	ICCV 6	1	1.55 -	0.24
Khargaone	ICCC 37	1	0.81 -	0.42
Mean			1.24 (± 0.20)	0.39 (± 0.06)

* from Agricultural situation in India 1987. The averages are always given for nonirrigated and irrigated crops together.

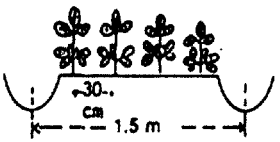
Figure 1. Basic structure of LEGOFTEN activities in India



ICAR : Indian Council of Agricultural Research
SAU : State Agriculture University
DOA : Department of Agriculture
DA : Development Agency

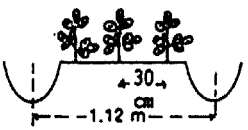
Figure 2. Raised Bed Systems for Growing Crops

a) Broad-bed and furrow



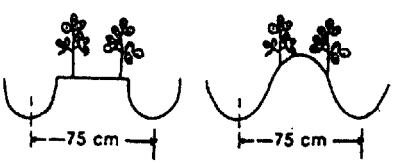
Ideal for rainy season and postrainy season under sprinkler irrigation in all soils.

b) Bed and furrow



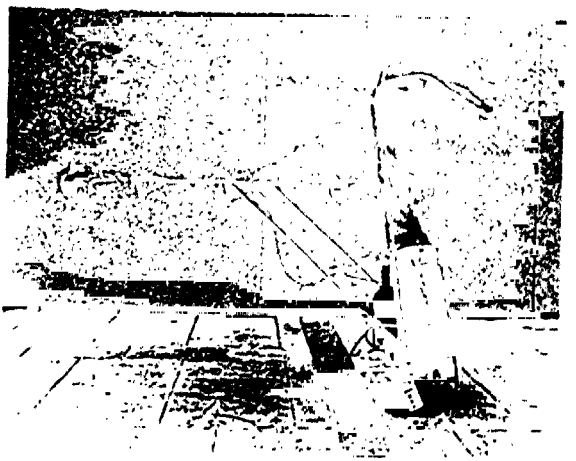
Ideal for rainy season and postrainy season under furrow irrigation in sandy-loam soils.

c) Narrow-bed and furrow/ridges and furrow



Ideal for postrainy season under furrow irrigation in black and lateritic-red soils.

Figure 3. Back-Pack Controlled Droplet Applicator (CDA)



i)	Weight of the empty sprayer	. 11.5 kg and 16.5 kg when filled
ii)	Spray boom height	. 0.3-2.5 m (adjustable)
iii)	Spray swath	. 3.0-3.6 m (adjustable)
iv)	Droplet size	. 150-250 u
v)	Spray liquid required	. 15-80 L (adjustable)
vi)	Time required/Ha	. 1 hr 30 minutes
vii)	Pesticide formulation required	. EC or WP

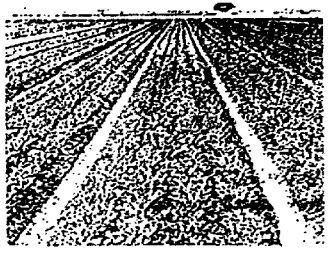
Figure 4. Raised bed systems: Basic idea

The raised-bed-and-furrow system

In black soils, particularly in high rainfall areas, make beds along a gentle slope

In red soils, make beds normally across the slope This helps to conserve moisture

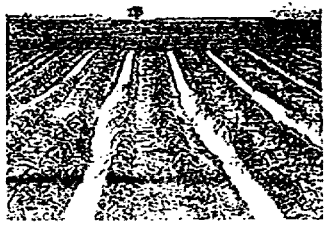
Crops be grown on raised beds separated by furrows



Marking the slope of the land

The raised beds should be on a slope of about 0.4-0.8% particularly in deep black soils (vertisols)

If the raised beds are completely level, there will be no drainage

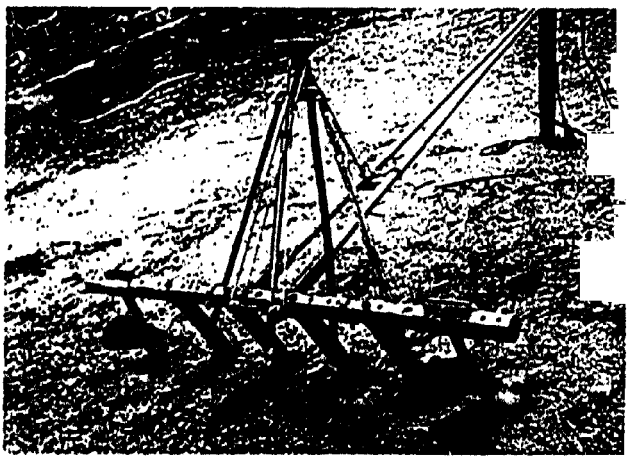


If the raised beds slope is too much the water will runoff, causing erosion

Figure 5. Seeding for individual row.

This is good practice for groundnut sowing.

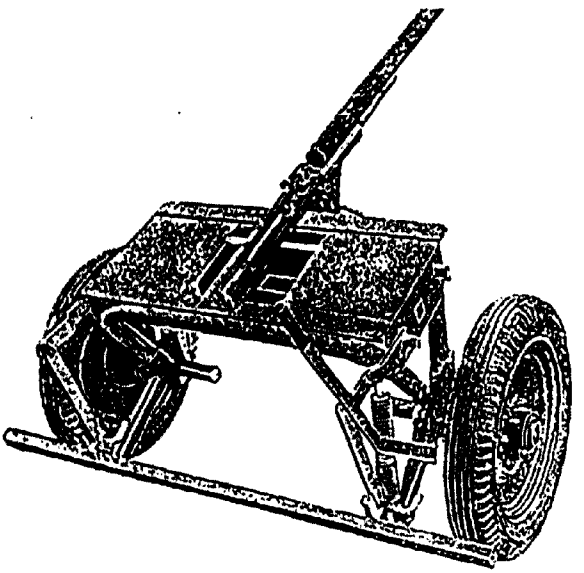
Figure 6. A seed-drill for seeding four rows together.



This is good for seeding pigeonpea and chickpea

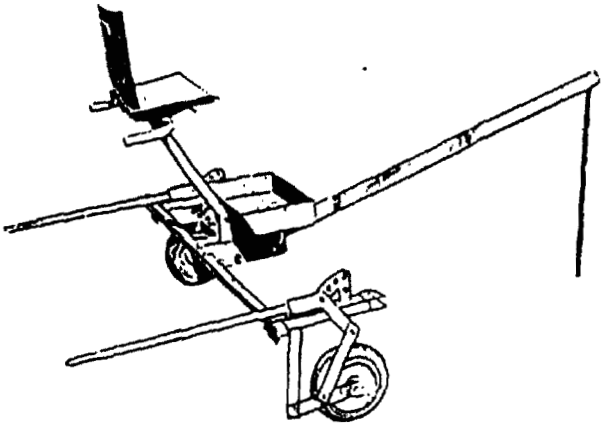
Figure 7. 'Punch and drop' method of dibbling groundnut seeds followed in some parts of Tamil Nadu.

Figure 8. A bullock-drawn wheeled tool carrier the tropicultor.



Rigid, sturdy, multipurpose machine. Heavy for most bullocks. It is costly too (Rs. 15,000 with implements)

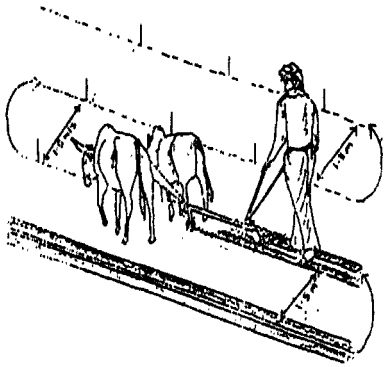
Figure 9. A bullock-drawn wheeled tool carrier the 'Agribar'

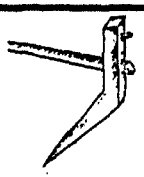


Rigid, study, light multipurpose machine. Suitable for most bullocks. Its cost is reasonable (about Rs. 5,000 with implements)

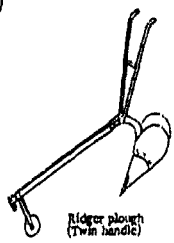
Figure 10. Indigenous implement used, developed and modified for bed preparation.

a) An indigenous bullock-drawn "wooden plough" or its replica "iron plough" (Balram Plough) or twin handle "ridger plough" can be used for opening furrows to prepare beds.





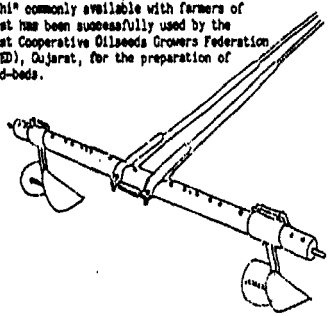
Wooden plough



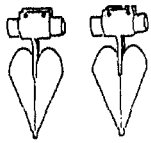
Ridger plough (Twin handle)

To prepare beds first open a furrow in a straight line, and then use this as a guide when opening successive parallel furrows. Some marking by fixing pegs in a straight line helps in driving the bullocks straight. Forming beds in a curved manner is not easy with this implement.

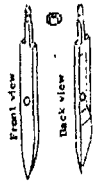
b) A bullock-drawn multipurpose implement called "Sasthi" commonly available with farmers of Gujarat has been successfully used by the Gujarat Cooperative Oilseeds Growers Federation (GROFED), Gujarat, for the preparation of raised-beds.



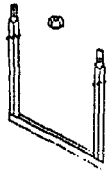
A specially designed furrow-opener can be fitted to the tool bar for forming raised-beds. The tool bar has provision to adjust the depth of any operation as per the pulling power of the bullocks in different soils.



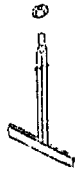
Furrow openers



Furrow opener-cum-seeding tine



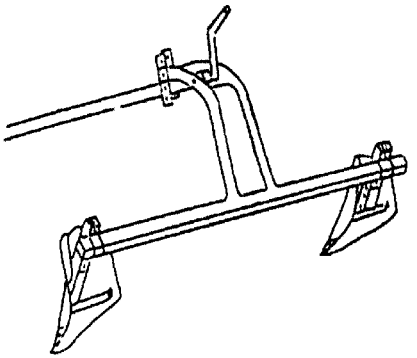
Harrow blade



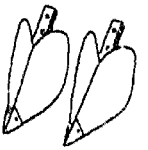
Interculture blade

Blades of different sizes, seed-furrow openers etc. are fitted to the tool bar (75 mm galvanised iron pipe) for various operations.

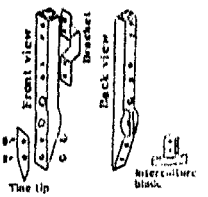
c) In the Marathwada region of Maharashtra a bullock-drawn bed former is fabricated by local manufacturers.



This implement consists of hollow a metal square tool bar (40 mm sq.) with a hollow pipe draw-bar(49 mm dia). It helps to form the beds only when the soil is in friable condition, which is obtained only after good rain or irrigation. This implement with all accessories costs Rs. 3000 to 4000/-.

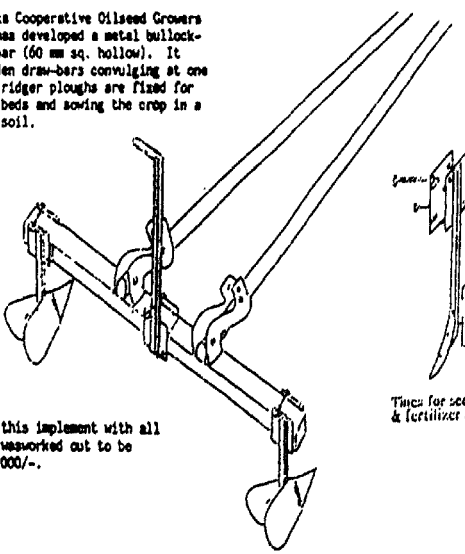


Furrow openers



Tine for seeding, fertilizer application and interculture

d) The Karnataka Cooperative Oilseed Growers Federation has developed a metal bullock-drawn tool bar (60 mm sq. hollow). It has two wooden draw-bars convulging at one point. Two ridger ploughs are fixed for forming the beds and sowing the crop in a well tilled soil.

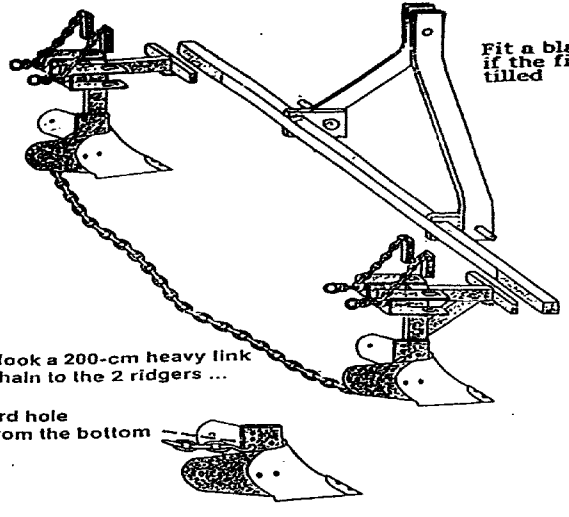


The cost of this implement with all accessories wasworked out to be around Rs. 1000/-.

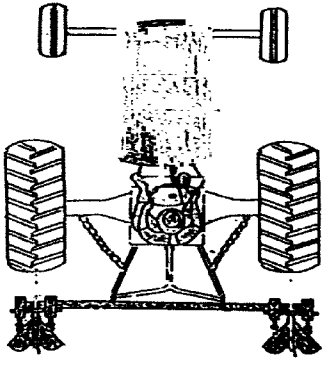
Tines for seeding & fertilizer application

Figure 11. Tractor drawn raised-bed maker.

Fit 2 ridgers and hook a chain between them.



Position ridgers exactly behind the wheels of the tractor



Annexure 1. Calender of major events on ICRISAT/GOI/ICAR - State's Departments of Agriculture collaborative trials on groundnut, pigeonpea, and chickpea.

Dates	Activity	Objective
23-24 Apr 1987	Meeting with high level officials of GOI, ICAR, and State Depts. of Agriculture.	To plan collaborative trials on groundnut.
11-15 May 1987	Training workshop for the collaborators of groundnut technology.	Training, identification of trial locations. Seed despatch.
30 Jun 1987	Setting-up of LEGOFTEN Unit with multidisciplinary team of scientists.	To implement the program.
25 Aug 1987	Meeting with the officials of GOI/ICAR and State Depts. of Agriculture.	To review the progress and and understand constraints from various states.
5-7 Oct 1987	Meeting with GOI and State Agriculture Officers.	Planning for postrainy season groundnut trials.
5 Apr 1988	Meeting with high level officials of GOI and States production commissioners on technology transfer in New Delhi.	To invite reactions of various states on groundnut technology and assess the needs on similar thrust in pigeonpea and chickpea.
25-26 Apr 1988	Meeting with high level officials of GOI and ICRISAT at ICRISAT.	To discuss and plan collaborative trials on pigeonepea and chickpea.
11-15 Apr 1988	Training workshop on pigeonpea and chickpea at ICRISAT.	To discuss contraints on yields of the two legumes, identify locations and varieties for on-farm trials.
17 Oct 1988	GOI approved the ESD pigeonpea trials received.	To test the potential of the ESD in the summer season.
25-26 Aug 1989	ICAR-ICRISAT Work Plan Meeting at ICRISAT.	ICAR-ICRISAT on-farm collaborative trials discussed. Two projects were approved.
17-21 Apr 1990	AICORPO Workshop, Bangalore	To decide ICAR-ICRISAT action plan for the rainy season groundnut 1990.

Dates	Activity	Objective
15-18 May 1990	AICPIP Workshop, Anand	To decide ICAR-ICRISAT action plan for the rainy season pigeonpea 1990.
23 May 1990	Meeting with senior officials of NDDB and SCOGF, ICRISAT Center.	To review the work on transfer of technology groundnut and plan work for 1990-91.
25-26 Sept 1990	AICORPO Workshop, Hyderabad	To decide ICAR-ICRISAT action plan for the postrainy season groundnut 1990-91.
20 Mar 1991	Meeting with NDDB and SCOGF Field Officers, Anand.	To review the transfer of technology for groundnut and plan work for 1991-92.
6-8 May 1991	AICORPO Workshop at GAU, Junagadh.	To decide ICAR-ICRISAT action plan for groundnut Kharif 1991.
3-6 May 1991	AICPIP Workshop, Varnasi	To decide ICAR-ICRISAT action plan for the rainy season program 1991.